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PROSPECTS OF UTILIZATION OF MODIFIED DISH TYPE SOLAR COOKER IN RURAL AREAS OF SIND, PAKISTAN

Shah, S.A.; Zulqarnain, Syed; Ahmed, Fawad; Faraz, S.; Asadullah, B.; Ubedullah, P.; Inamullah, P.

Department of Mechanical Engineering MUET SZAB,
Khairpur Mir's 66020, Pakistan

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Abstract:
Fossil fuels such as coal, natural gas, liquefied petroleum gas and biomass energy sources and residues are generally used to cater energy needs for cooking in rural and urban areas of Pakistan. However, natural gas and liquefied petroleum gas and coal are finite and are incapable to cope up with growing energy needs of population. Solar energy can be utilized as an alternative fuel for cooking using solar cookers in Sind, Pakistan. A Dish Type Solar Cooker of 4ft (122cm) with a collector covering its surface with a reflective Chrome-Silver-Mirror-Tint –Film is developed and is tested in two modes, one with bare and covered pot. A solar mechanical tracker is adjusted for changing the angle of collector every 20-30 minutes, which yielded promising results in terms of cooking food in efficient and effective manner.

Keywords: *Solar Cooker, Dish type, Portable, Collector*

1. INTRODUCTION:

Due to the finite nature of fossil fuel and their Environmental Hazards, which are used traditionally used for meeting cooking energy needs on small, medium and large scale, gradual switching over to renewable Energy is considered a feasible option and is the key energy issue in the world. Among renewable energy sources solar energy is considered a sustainable and reliable energy source in tropical parts of the world [1]. Fortunately, Pakistan lies in the tropic region and is replete with solar energy and seems feasible option to cater various energy needs, as is illustrated in annual solar irradiance data, which shown in figure 1.

There are various dimensions of solar energy utilization. Solar energy can be utilized as a source for electrical power generation, space heating, space cooling, drying and cooking [2]. Solar energy can be utilized using solar cookers to cook food on small, medium and large scale in the world. Solar Cookers have the potential to replace traditional cooking fuels in Sind, Pakistan because of abundance of solar Energy available in these areas throughout the day and round the year in environment friendly manner.

There are various types of solar cookers, which are used worldwide to cater cooking energy needs. The two most common designs include box type and parabolic concentrator type. Various developments are made worldwide on the utilization of solar cookers. Box and parabolic Type solar cookers designs are largely used for cooking food on small scale [1]. Cylindrical trough shape solar cooker designs are also used for cooking on both community and domestic levels [3,4]. Ssatellite dish

technology is also used for solar cooking applications [5]. Portable solar cooker and water heater with parabolic dish concentrator are also used, which have better energy and exergy efficiencies [6]. The efficiency of the solar cookers can be increased and cooking time can be reduced by modification in the design parameters [7].

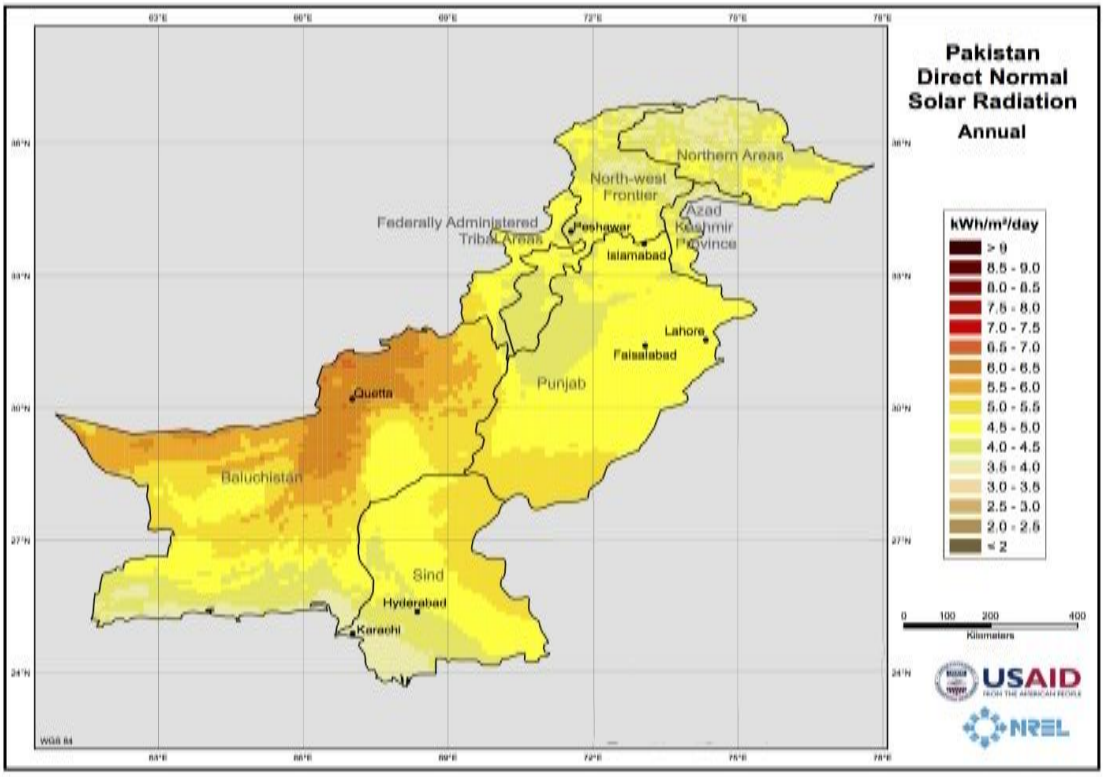

Figure 1: Annual Solar Irradiance data of Pakistan

Since cooking needs of people in Pakistan are met by the use wood burning, natural gas liquefied petroleum gas. However, these entire energy sources are unsustainable and cannot be considered as affordable option for meeting cooking energy needs of the people. There is dire need of an alternative renewable and sustainable energy source, which can cater not only cooking energy needs reliably but also is accessible to the people living equally in rural and urban areas of Sind, Pakistan.

The prospects of modified design of dish type solar cooker utilization are analyzed. A slight variation in one of the design parameters i.e. in the curvature of the concentrator is made in order to investigate its effect on the performance of solar cooker both in covered and uncovered pot mode.

2. Materials and Methodology

The material, which are used for frame/stand is mild steel. Dish/Concentrator is mounted on the central mild steel having rod of length 150cm, which is supported by a frame/stand. The focal length of pot holder/absorber is 37cm from the center of concentrator/dish and has diameter of 25cm.The angle of the dish is adjustable manually by tightening/losing the bolt on either side of the dish. Proposed dish type solar collectors is shown in figure 3 and 4.

The dish type solar cooker parameters comprise of focal length, concentration ratio, aperture area, cooking power and efficiency. These parameters are calculated theoretically on basis of the input data obtained on proposed site at Khairpur, Sind Pakistan.

A software "parabolic calculator 2.0 is also used for the calculation of these parameters and their results are compared with the results of theoretical design parameters.

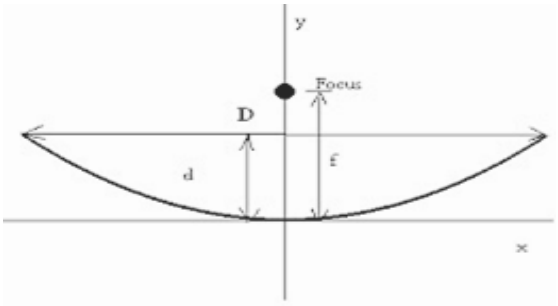

Figure 2: illustrate Diameter, Focus and Depth of Parabola

3. Results and Discussion:

The first design parameters, of proposed dish type solar cooker is focal length/distance, which is Distance from the Focus to the Vertex of Parabola, and is calculated by the following expression;

$$f = \frac{Da^2}{16h}$$

Where D_a is the aperture diameter and h is the height. The other parameter of dish type solar cooker is concentration ratio, which is the ratio of Aperture area to absorber area and is calculated by using the following expression;

$$C_{area} = \frac{A_a}{A_{abs}}$$

Where D_a is the aperture diameter and h is the height. The other parameter of dish type solar cooker is concentration ratio, which is the ratio of Aperture area to absorber area and is calculated by using the following expression;

$$A_a = \frac{\pi Da^2}{4}$$

Where *Da* is the diameter of the absorber. The cooking Power is an important parameter in solar cooker and is calculated by using the following relationship.

$$P = \frac{mC_p\Delta T}{t}$$

Where m is the mass of the liquid in the pot $C_p$isthe Specific heat and $\Delta T$is rise in the temperature of water and *t* is the cooking time of the test. The efficiency of the cooking process is calculated by using the following expression:

$$\eta = \frac{mC_p\Delta T}{tA_a\mathrm{G}} = \frac{P}{A_a\mathrm{G}}$$

Where G is the Solar Irradiance in W/m^2.

Following results are obtained by using above formulas

- ✓ D= 122cm
- ✓ Depth = 25cm
- ✓ $f = 37.21$
- ✓ $C_{area} = 23.63$
- ✓ $A_a = 1.16m^2$
- ✓ $A_{abs} = 0.049m^2$

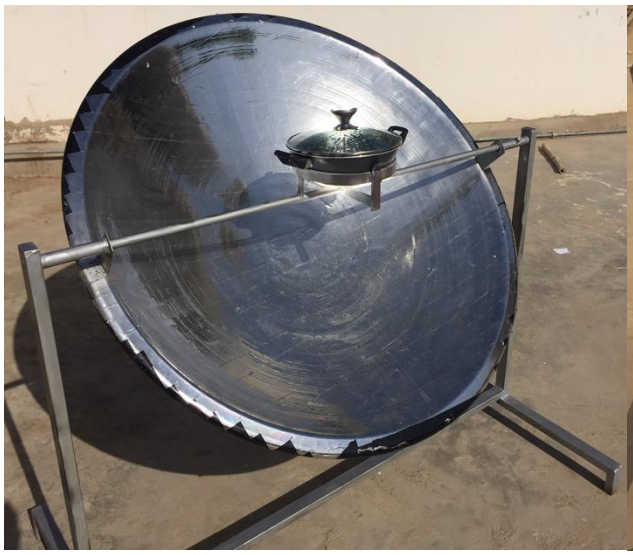

Figure 3: The Solar Cooker while cooking

Figure 4: The Solar Cooker

Cooking Power and Efficiencies of solar cooker were calculated as shown in table.1 and table.2 and their corresponding graphs shown in figure 5 and figure 6.

Table 1. Power required v/s Output

Sr. #	Time (min)	Mass of Water (kg)	Power Required (W)	Power Output (W)
01	20	1	259.8566667	191.8833333
02	35	2	296.9790476	231.0333333
03	50	3	311.828	262.9333333
04	65	4	319.8235897	302.0833333
05	80	5	324.8208333	320.9333333
06	95	6	328.24	325.2833333
07	110	7	330.7266667	300.15
08	125	8	332.6165333	280.8166667
09	140	9	334.1014286	273.5666667
10	155	10	335.2989247	241.1833333
11	170	11	336.285098	199.1333333
12	185	12	337.1113514	175.9333333

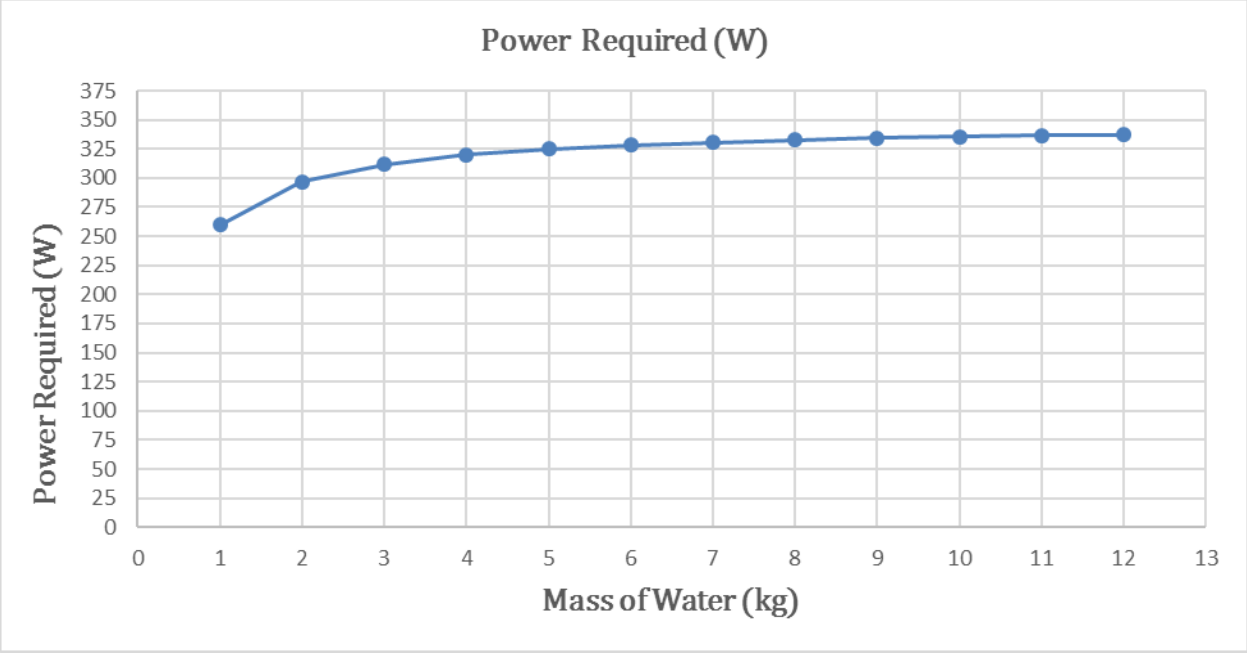

Figure 5: Power v/s Mass of Water

Table 2. Annual Efficiency

Sr. #	Month	Efficiency
01	January	0.580187063
02	February	0.698562761
03	March	0.795017033
04	April	0.913392731
05	May	0.970388438
06	June	0.983541293
07	July	0.907547018
08	August	0.849089883
09	September	0.827168457
10	October	0.729252757
11	November	0.602108488
12	December	0.531959927

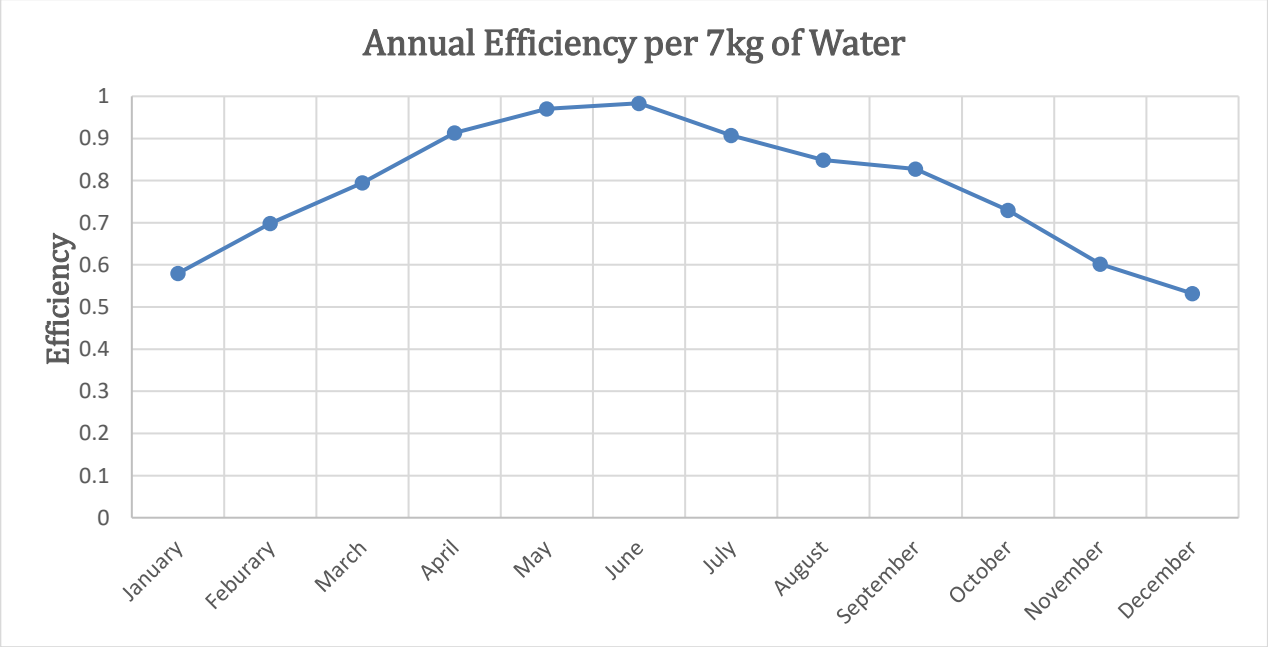

Figure 6: Annual Efficiency for Cooking

High efficiency and power can be obtained as per the monthly solar irradiance data of the place. By analyzing Table 2, it can be said that power obtained during the month of May & June is increased by 45 % compared to the month of December due to the available maximum solar irradiance value.

The proposed dish type solar cookers have potential to produce required amount of cooking energy and is capable to replace traditional fuel and cooking appliances in rural and urban areas of Sindh, Pakistan. There is considerable scope of solar cookers in Sindh, Pakistan and these can be used in those underdeveloped areas, where traditional fuels have failed miserably.

4. Conclusion:

It was found that 7 Kg of water at 25 ^{o}C with pot covered was bought to boil at approximately 99.6 ^{o}C in 110 min which is very high compare to conventional flat-plate Designs. An increase in efficiency as much as 45 % was found during the month of June with an uncertainty of ±1.7%. Using glass box for pot during cooking, it was found that efficiency and cooking power increased by 38% & 275% respectively. If considerable support is provided in terms of material resources portable dish type solar cookers can be manufactured on small, medium and large scale.

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